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Original Research

Can new anthropometric indices be used as a marker for the presence of metabolic syndrome?

New anthropometric indexes and metabolic syndrome

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Abstract

Aim: Since traditional anthropometric measurements such as waist circumference (WC) and body mass index (BMI) can not adequately demonstrate muscle, fat mass, and body fat distribution, new indices have been developed taking into account the shape of the body. In this study, we aimed to investigate whether new anthropometric indices such as Rohrer Index (RI), Body Shape Index (BSI), and Body Roundness Index (BRI) can be used as markers for the presence of metabolic syndrome or not.

Materials and Methods: This study was performed on 1059 patients who met the inclusion criteria. Waist-to-height ratio (WHtR), BMI, BRI, BSI, RI were calculated using the appropriate anthropometric measurements taken from the files of the participants.

Results: The prevalence of metabolic syndrome was 39.9% (n=423). There was a statistically significant relationship between BMI, WHtR, RI, BSI, BRI and gender, age, and metabolic syndrome (p<0.001). While there was a weak positive correlation between BSI and metabolic syndrome (r=0.182, p<0.001), there was a strong positive correlation between BRI and metabolic syndrome (r=0.610, p<0.001). The optimum cutting values for BMI, WHtR, and BRI were determined as 30.19 kg/m2, 0.59 cm and 5.24, respectively.

Discussion: BRI and WHtR were found to have a higher capacity to predict metabolic syndrome than other indices (BSI, RI, BMI), however, it was seen that it was not superior to BMI. Other anthropometric indices can be used as well as BMI and waist circumference for the prevention, early diagnosis, and detection of the metabolic syndrome risks in the primary health care centers.

Keywords

Metabolic syndrome; Obesity; Anthropometry; Adults; Primary health care

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Introduction

Metabolic Syndrome (MetS) according to the Endocrine and Metabolism Association an increasingly common health problem in the world and in our country, is defined as a complex disease consisting of the collection of biochemical, physiological, clinical and metabolic factors that are associated with systemic disorders such as abdominal obesity, glucose intolerance or diabetes mellitus, dyslipidemia, hypertension and coronary artery disease (CAD). Genetic and environmental factors, age, obesity, physical inactivity, irregular eating habits and stress play an important role in the development of metabolic syndrome [1]. MetS exists in about one-third of the adult population in the world and in our country, and this frequency increases with age [2].

Visceral adiposity, known as central or abdominal obesity, is an important component of the metabolic syndrome. Abdominal obesity has been shown to be correlated with many pathophysiological conditions such as insulin resistance, impaired lipid metabolism and endothelial dysfunction [3-6]. According to the World Health Organization (WHO), in 2016, there were 1.9 billion overweight and 650 million obese adults around the world. The prevalence of obesity in the world almost tripled between 1975 and 2016. According to the results of the research conducted by the endocrine and metabolism association, Turkey was reported to have the highest prevalence of obesity in Europe, with a prevalence of 29.5%.

Body mass index (BMI=Weight(kg)/Height(m2)) which is an anthropometric measurement is a common, cheap and useful method used to define overweight and obesity. Other than BMI, waist circumference (WC), waist-to-height ratio (WHtR) and waist-hip ratio (WHpR) are also used to predict obesity and especially central obesity. However, the BMI does not provide information about muscle mass, fat mass and body fat distribution. Due to these limitations of direct measurements, the researchers have searched for new anthropometric indices to better identify diseases which cause obesity and metabolic syndrome. The body shape index (BSI) is a new anthropometric measurement recommended as a predictor of early obesity-related deaths, regardless of BMI. BSI is calculated using waist circumference, BMI, and height. Krakauer et al. (2012) revealed that BSI was more predictive of premature mortality than BMI or WC [7]. Body roundness index (BRI) is a measurement created by Thomas et al. (2013) which combines height and waist circumference to predict the percentage of body fat mass (FM%) and to assess the patient's health status [8]. This index is derived to measure the height-independent body shape as an estimator of FM% and visceral adipose tissue (VAT). Researchers modeled the shape of the human body as an ellipse or an oval shape surrounding the body according to roundness. Thus, it can be applied as a visual aid to compare the body types and determine the position of the body type according to the reference range of healthy body roundness [8]. The waist-to-height ratio (WHtR) is a simple and effective anthropometric index [9], and it can be used equally to men and women to define central fat distribution in normal or overweight individuals with high metabolic risk, regardless of body weight and fat distribution. WHtR≥0.5 is considered as abdominal obesity [10]. While the BMI measures two-dimensional square plate of the body, and weight per square area, the Rohrer index (RI) is a three-dimensional cube of the body and measures the weight per cubic content. Therefore, RI takes into account the width and circumference of the person, unlike the measurement of BMI, and assumes that the width and circumference are proportional to the height of one [11].

We aimed to investigate whether new anthropometric indices, such as Rohrer Index (RI), Body Shape Index (BSI) and Body Roundness Index (BRI), can be used as a marker of the presence of metabolic syndrome or not.

Material and Methods

Place, type and universe of research

This study was planned to be conducted as a retrospective screening of the files of patients over 18 years of age who applied to the Family Practice outpatient clinic for any reason between the years of 2016-2018. Since the prevalence of metabolic syndrome and obesity was approximately 30% in our country, it was planned to enroll at least 450 patients in our study with a 5% error share and 95% confidence interval. Among 2000 patients who got examined and had files in our outpatient clinic between the years of 2016-2018, 1059 were included in the study by taking into consideration study exclusion criteria.

Ethical authorization of the study

Ethical approval was received from Necmettin Erbakan University, Meram Medical Faculty, Ethics Committee (Number: 2019/1807) before the study started. All participants provided electronic informed consent.

Data collection

Sociodemographic characteristics such as age, gender, marital status, educational levels were recorded. Smoking status and anthropometric measurements such as height, weight and waist circumference, systolic/diastolic blood pressures and the results of fasting blood glucose (FBG) and lipid parameters were measured.

Exclusion criteria

Those with a lack of information in the file, with congenital or acquired body anomalies, who have cancer, with a disease that affect blood glucose and lipid parameters and who use drugs for this, who have bone, endocrine and metabolic diseases, pregnant women and puerperants, those who receive medical or surgical obesity treatment and receive hypertension treatment and those under 18 years of age were excluded from the study.

Anthropometric indices

Anthropometric indices were calculated by following formulas:

1. Waist to Height ratio (WHtR): Waist circumference (cm) / Height (cm);
2. Body Mass Index (BMI): Weight (kg) / Height2 (m);
3. Rohrer Index (RI): Weight (kg) / Height3 (m);
4. Body Shape Index (BSI): Waist circumference (cm)/ (BMI2/3*Height1/2(m));
5. Body roundness index (BRI):364,2-365,5√[1-(waist circumfer ence/2π)2/0,5*Height(m))2]

The diagnosis of metabolic syndrome

We used the most widely used and accepted criteria for the diagnosis of Metabolic Syndrome. According to this, three or more of the following findings are diagnosed as metabolic syndrome [12].

- Abdominal obesity (waist circumference: >102 cm for men, >88 cm for women);
- Hypertriglyceridemia (≥150 mg / dl);
- Low HDL (<50 mg/dl for men, <40 mg/dl for women);
- Hypertension (≥130/85 mmHg);
- Fasting blood glucose ≥100 mg/dl or Type 2 diabetes mellitus.

Statistical analysis

When the findings of the study are evaluated, SPSS (Statistical Package for Social Sciences) for Windows 21.0 software program was used for statistical analyzes. Frequencies, mean, standard deviation, median, minimum and maximum values were calculated. The Chi-square test was used to compare categorical data. The appropriateness of the normal distribution of the quantitative data was evaluated with the Kolmogorov-Smirnov test. For non-parametric data, the Mann-Whitney U test was used in binary groups. The relationship between the groups was evaluated with the Spearman's rank correlation test. The significance level was accepted as p<0.05. To compare the predictive ability and to determine the optimal cut-off values for multiple metabolic risk factors of obesity indices (ROC) analyzes were used. The cutoff points for each anthropometric indicator were identified using the Youden index.

Results

The mean age of patients in our study was 36.30±12.1 years, 68.1% (n=721) of them were female, 74.4% (n=788) were married, 36.1% (n=382) were university graduated, 26.1% (n=276) were officers and 26.6% (n=282) were smokers. The mean BMI of the participants was 30.20±7.2 kg/m2, while 52.3% (n=554) of them had BMI <30 kg/m2 normal/overweight and 47.7% (n=505) had BMI ≥ 30 kg/m2 obese. In this study, 41.1% (n=39) of men had waist circumference ≥102 cm and 66.4% (n=479) of women had a waist circumference >88 cm. Among the participants, 93.1% of men who were obese and 87.4% of women who were obese had wider waist circumference (p<0.001).

The mean WHtR of the participants was 0.58±0.1 (0.22-1.09) and 79.7% (n=844) of them had abdominal obesity with WHtR≥0.5. The RI mean was 18.51±5.6 (8.46-117), BSI mean was 7.73±0.7 (2.46-10.92) and BRI mean was 5.18±2.2 (-0.44-21.4). When we compared the anthropometric indices and genders, the mean values of BMI, WHtR, RI and BRI were higher in females than the males, while the mean BSI was higher in males (p<0.001).

When the age of the participants was compared with the anthropometric indices, the mean values of BMI, WHtR, RI, BSI and BRI were statistically significantly higher in the individuals over the age of 35 than those who were under the age of 35 years (p<0.001). The mean values of WHtR, RI and BRI were higher in the obese patients than those with normal/overweight patients, while the mean BSI was lower (p<0.001, p=0.016) (Table 1).

In our study, the prevalence of metabolic syndrome was found as 39.9% (n=423). The significant relationship between BMI, WHtR, RI, BSI, BRI and the existence of metabolic syndrome was found (p<0.001). Anthropometric indices were higher in patients with metabolic syndrome than in patients without metabolic syndrome (Table 2).

According to the Pearson correlation analysis between anthropometric indices, age and metabolic syndrome criteria, there was a positively poor correlation between BSI and metabolic syndrome ((r=0.181, p<0.001), while there was a moderate correlation between age and RI levels (r=0.351, r=0.452, p<0.001), and strong significant relationship between BMI, WHtR and BRI (r=0.537, r=0.619, r=0.610, p<0.001).

Roc analyzes were performed to compare the predictability of obesity indices. The area under the ROC curve in patients with metabolic syndrome (AUC) was 0.826 for BRI and WHtR, 0.790 for BMI, and 0.618 for BSI (Figure 1). The cut-off values, sensitivity and specificity of anthropometric indices according to the criteria of metabolic syndrome are shown in Table 3.

Table 1. Comparison of anthropometric indices by gender, age and BMI

	Female Mean+SD	Male Mean+SD	t	p*
WC	93.93±15.4	98.30±15.0	-4.260	<0.001
BMI	31.05±7.7	28.37±5.5	-5.640	<0.001
WHtR	0.58±0.1	0.56±0.1	-3.061	0.002
RI	19.52±6.2	16.37±3.3	-10.159	<0.001
BSI	7.58±0.7	8.05±0.6	-11.897	<0.001
BRI	5.35±2.3	4.84±1.8	-3.061	0.002
	≤35 AGE Mean+SD	**>35 AGE Mean+SD**	**t**	**p***
WC	91.04±14.7	100.17±14.7	-10.039	<0.001
BMI	28.69±7.7	31.90±6.1	-8.709	<0.001
WHtR	0.55±0.1	0.61±0.1	-11.233	<0.001
RI	17.51±6.5	19.64±4.2	-8.831	<0.001
BSI	7.63±0.6	7.84±0.7	-6.236	<0.001
BRI	4.53±2.1	5.92±2.1	-11.233	<0.001
	BMI<30 kg/m2 Mean+SD (n=554)	**BMI ≥30 kg/m2 Mean+SD (n=505)**	**t**	**p***
WC	86.35±11.0	105.17±13.4	-24.977	<0.001
WHtR	0.51±0.1	0.65±0.1	-23.924	<0.001
RI	15.08±2.3	22.28±5.9	-27.398	<0.001
BSI	7.80±0.6	7.65±0.8	-2.404	0.016
BRI	3.76±1.2	6.75±2.0	-23.924	<0.001

* BMI: Body Mass Index. WHtR: Waist/Height ratio. RI: Rohrer index.
BSI: Body shape index, BRI: Body roundness index, WC: Waist Circumference

Table 2. Comparison of metabolic syndrome and anthropometric indices

	MET S (-) n=636	MET S (+) n=423	t	p
WC	88.87±13.3	105.03±13.1	-19.427	<0.001
BMI	27.55±5.7	34.18±7.4	-15.993	<0.001
WHtR	0.53±0.1	0.64±0.1	-17.997	<0.001
RI	16.75±3.8	21.17±6.8	-15.085	<0.001
BSI	7.63±0.7	7.88±0.7	-6.518	<0.001
BRI	4.23±1.7	6.62±2.1	17.997	<0.001

* BMI: Body Mass Index. WHtR: Waist/Height ratio. RI: Rohrer index.
BSI: Body shape index, BRI: Body roundness index, WC: Waist Circumference

Table 3. Cut-off points of anthropometric measurements in patients with metabolic syndrome

	MALE	AUC (95%CI)	Cut-off value	Sensitivity (%)	Specificity (%)
MET S	WC	0.794 (0.744-0.844)	101.5	77.0	72.9
	BMI	0.783 (0.734-0.832)	28.72	72.6	72.4
	WHtR	0.803 (0.755-0.851)	0.57	74.1	73.9
	RI	0.783 (0.733-0.832)	16.5	74.1	73.9
	BSI	0.622 (0.561-0.682)	8.13	61.5	61,6
	BRI	0.803 (0.755-0.851)	4.88	74.1	73.9
	FEMALE	**AUC (95%CI)**	**Cut-off value**	**Sensitivity (%)**	**Specificity (%)**
MET S	WC	0.837 (0.808-0.866)	95.5	76.4	75.1
	BMI	0.800 (0.768-0.831)	31.24	71.9	71.8
	WHtR	0.839 (0.810-0.868)	0.59	76.0	76.0
	RI	0.793 (0.760-0.825)	19.5	72.2	71.8
	BSI	0.630 (0.589-0.671)	7.61	58,3	58,2
	BRI	0.839 (0.810-0.868)	5.41	76.0	76.0

*AUC: Area under curve BMI: Body Mass Index. WHtR: Waist/Height ratio. RI: Rohrer index. BSI: Body shape index. BRI: Body roundness index, WC: Waist Circumference

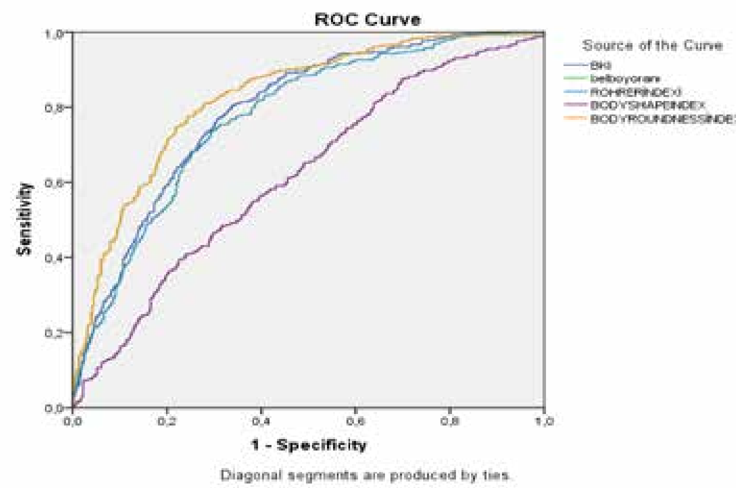

Figure 1. ROC curve of anthropometric measurements in patients with metabolic syndrome

Discussion

According to the World Health Organization, BMI provides the most useful measurement of overweight and obesity. However, there is a need for new indices to predict adiposity, as it does not take into account body shape which changes by body fat, muscle mass, age and disease. In this study, we determined the relationship between these anthropometric measurements and metabolic syndrome.

While the mean values of BMI, WHtR, RI and BRI were higher in females than males, the mean value of BSI was higher in males. The mean values of BMI, WHtR, RI, BSI and BRI in those over the age of 35 were higher than those aged 35 years or younger and anthropometric index values were also increased with age. Similarly, Solak et al. found that BSI and WHtR values were higher in men than women and BMI and BRI values were statistically higher in women than men in their studies conducted with 288 patients in 2018 [13]. In this presented study, the frequency of the metabolic syndrome was found as 39.9% (35.9% in men and 40.2% in women). In a community-based multicenter study in our country, the prevalence of MetS was found to be as 28% in males, 39.6% in females and 33.9% in general [2]. Similar to our study, in Kutlu and Civi's study, MetS frequency was 44.1% (49.0% in women and 31.2% in men). The prevalence of MetS in women was 2.11 times higher than in men [14]. In our region, the prevalence of MetS was observed to be higher than the country average due to the eating habits and lifestyle. In a study with 379 patients aged 40-65 years in China who were followed for 4,5 years, the prevalence of metabolic syndrome was found to be as 33.2% (37.8% in men and 23.9% in women) [15]. In another study conducted by Gülmez et al. in 2017, the prevalence of Met S was found to be 22.3%. They found that patients with MetS had significantly higher BMI, WC and neck circumference measurements than patients without MetS, and that neck circumference could be used as a valuable measurement method such as WC for MetS [16]. In our study, we found that the measurements of WC, WHtR, BMI, BSI and BRI were significantly higher in those with MetS than in those without MetS.

In our study, according to correlation analysis between age and metabolic syndrome criteria and anthropometric indices, there was a strong positive relationship with BMI, WHtR and BRI but a poor relationship with BSI was found. In the study by Zaid et al. which compared BSI and BRI for the capacity to assess the type and severity of dyslipidemia, they demonstrated that BRI was capable of predicting dyslipidemia, but not precede BMI and WC. On the other hand, BSI could not detect the presence or absence of dyslipidemia [17]. In a case-control study of 505 patients with and without diabetes mellitus, no significant correlation was found between HbA1c and FBG levels and anthropometric indices in patients with diabetes and they found that anthropometric indices have limited capacity and usefulness in monitoring diabetes and dyslipidemia [18]. In a study on 4395 people in Korea, both men and women showed a stronger correlation between WHtR and metabolic risk factors than BSI and found AUC values as 0.849 and 0.676, respectively. They found that WHtR had better predictive power for the metabolic syndrome [19]. In our study, compatible with the literature, the predictive values of BRI and WHtR for MetS (0,826-0,826) were found better than BMI, while the predictive values of BSI (0,618) were found very low. In a study which calculated BRI and BSI predictive values for overweight and obesity, BRI was found to have better predictive values for obesity than BSI [13]. In another study on 206 people selected according to MetS criteria, WC and WHtR were found to be better than BMI in predicting metabolic syndrome and it was reported that WHtR could be used in the diagnosis of MetS [20]. In a multicentre study with 1885 people followed for 3 years, followed by annual measurement of WC, BMI and WHtR and OGTT, WHTR value was found to be more successful than other measurements in prediabetes prediction [21].

In our study, the cut- off value for WC was 95.5 cm in women and 101.5 cm in men with MetS. According to data of the

Association of Endocrine and Metabolism of Turkey for the Turkish population, ≥100 cm in men and ≥90 cm in women is proposed as abdominal obesity criterion.

The study by Gu et al. conducted with 5685 people in 2018, showed that BMI, WC, and WHtR could similarly predict MetS in men (0.698 - 0.691 - 0.688) in men and MetS in women (0.676 - 0.666). The optimum cutting values of BMI, WC, and WHtR in the diagnosis of MetS in men were 24.1 kg/m2, 83.5 cm, and 0.51, respectively while these values were found to be 23.5 kg/m2 and 77.5 cm in women [22]. In another study, the strongest predictor of MetS for men was BMI (0.770) and abdominal volume index (AVI) for women was (0.720). However, no significant difference was observed between WC and these two indices. In contrast, it was found that BSI did not adequately predict MetS in both genders [15].

In conclusion, we found that BMI, WHtR and BRI measurements predicted MetS more accurately than other anthropometric measurements in predicting metabolic syndrome. The most important limitation of the study was that the study was conducted in a tertiary health care facility, so it may not represent the community. To identify the relationship between obesity indices and metabolic risk factors, multi centers, bigger samplings and more comprehensive studies are needed. These anthropometric measurements are simple and easy, so these tests can be easily used in practice, especially in primary health care facilities.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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